USING MULTIRESOLUTION TREE TO INTEGRATE MODIS AND MISR-L3 LAI PRODUCTS

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ABSTRACT

Leaf Area Index (LAI) is one of Essential Climate Variables (ECV) defined by many organizations such as Global Climate Observing System (GCOS) and Food and Agriculture Organization (FAO) [1], because of its importance in modeling photosynthesis, crop yield and hydrological cycling etc. Long term consistent observations of LAI are vitally important to understand the Earth system and its change. The new generation multispectral sensors, such as Moderate Resolution Imaging Spectroradiometer (MODIS), have been significantly improved in spatial and spectral resolutions and radiometric and geometric accuracy. Multi-angular sensors (e.g. Multi-angle Imaging SpectroRadiometer (MISR)) observe the Earth from several viewing angles and are thought to improve the accuracy of surface characterization. Sophisticated algorithms have been developed to generate global LAI products from MODIS and MISR data on a regular basis. The requirement for LAI accuracy is 0.5 defined by GCOS for climate study and other applications may need even higher quality. However, none of existing products have such higher accuracy. Besides, LAI data gaps and inconsistency among data may also limit their application. For example, high quality retrievals (from the main algorithm with favorable atmospheric condition) from MODIS LAI products for broadleaf trees in the growth season may be less than 20% of total available data.

Several attempts have been made to improve the retrieval quality of LAI data. One way is to continue developing sophisticated algorithms, such as introducing spatial [2] or temporal [3] prior knowledge. The other way is post-process current LAI products using various methods such as optimal interpolation [4], temporal spatial filter [5] and singular spectrum analysis [6]. This paper follows the second way. However, all of these methods use only one source of LAI data. The MultiResolution Tree (MRT) method employs the Kalman filtering on a multi-level tree structure and is able to efficiently incorporate data with various resolutions [7]. This method was introduced by Chou [8] and has been extensively used to interpolate and filter satellite altimetry data [7, 9], temperature [10], soil moisture [11] and so on. However, MRT has never been used to address the abovementioned problems of satellite LAI products. This paper presents the first study to apply the MRT method to integrate MODIS and MISR L3 LAI products to achieve the goal of improving the integrality and accuracy of LAI data.

Besides MODIS and MISR LAI products, this paper also needs field measurement for the validation purpose. Due to the heterogeneity of LAI data and the change of support problem, high resolution LAI maps, which are calibrated with field measurements, are suggested [12]. Twenty-eight high resolution LAI reference maps across North America are collected from several LAI validation campaigns or programs.

MISR L3 data is re-projected to the sinusoidal projection with the pixel size of 64 km. So, MISR takes the level 3 and MODIS LAI is the finest level. Direct comparison with high resolution LAI maps is used to obtain the measurement error for MODIS data. Intercomparison with aggregated MODIS data is used to characterize the errors of MISR L3 data. In addition to the measurement error, another parameter is the variance of the state estimates. This parameter is empirically calculated using aggregated MODIS data at different levels.

MRT is first carried out at these validation sites using only MODIS data. The preliminary results are shown in Fig.1. Compared with the original MODIS data, the MRT results have smaller bias and higher correlation with the reference maps. R^2 is improved from 0.75 to 0.78, bias is reduced from 0.28 to 0.14 and RMSE decreases from 1.04 to 0.82.

To further demonstrate the MRT ability on two dimensional images, the data of August 2001 covering MODIS Tile H10V5, most of which is over land, are used to test our algorithm. MRT integrated results are shown in Fig. 2. The MRT integrated results are gap-free and smoother than the original anomaly map. The inconsistency among input data at different levels is mitigated through the data integration process. All the results are consistent cross the scales. The MRT errors are also shown, which mainly depend on the availability of input data and the accuracy of available data. Judging from MODIS QC, the left lower part of the image has lower data quality, and thus larger MRT error. However, the estimation errors are reduced through MRT, compared with the original measurement error.

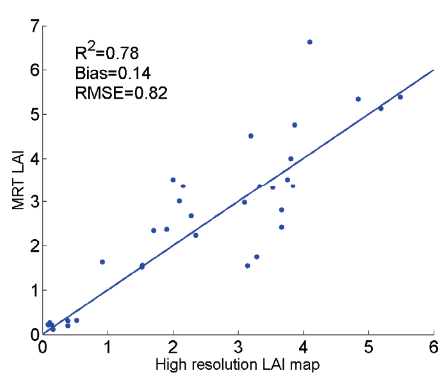

Fig.1 Validation of MRT results using aggregated high resolution LAI reference maps

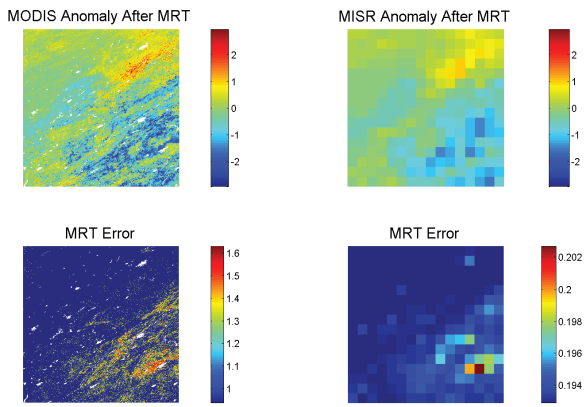

Fig. 2 MRT integrated LAI anomaly and its error at MODIS and MISR scales

OI is also carried out over the same image to compare with the MRT method. MRT produces similar results with OI but with significantly improved efficiency (Fig. 3). Large differences appear in the left lower part of the map, where the original products have large errors.

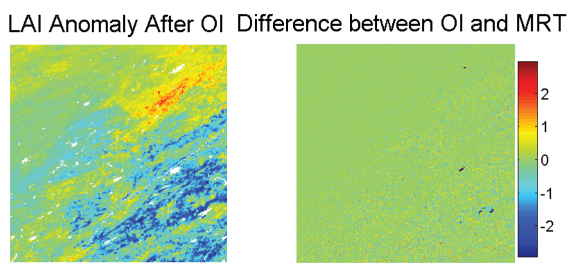

Fig. 3 OI processed LAI anomaly and its difference with MRT results

The improved mapping of LAI will improve modeling of vegetation dynamics and evaluating terrestrial productivity with higher accuracy and more integrality. The proposed method can also be applied in other satellite land products with similar problems.

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